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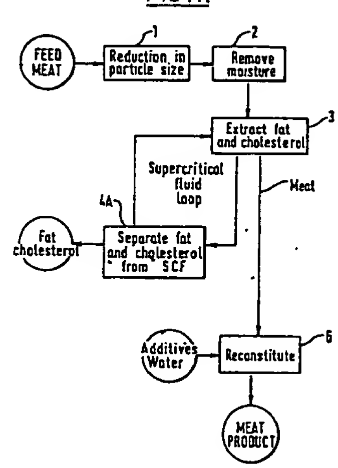
(54) **Removal of lipids from foodstuffs.**

(57) A process for the removal of sterols and/or lipid components (eg, cholesterol and fats) from lipid containing food (eg, meat) using sub or super-critical fluids (eg, CO_2) involves initial processing of the food to produce an intermediate moisture product in which substantially al of the "free water" but not all of the "bound water" is removed. Different moisture removal techniques may be used. When freeze drying of food flakes is adopted the moisture level is preferably reduced to 30-55% w/w. The intermediate moisture product is treated with supercritical CO_2 to remove the lipids therefrom. Optionally the cholesterol can be separated from the fat component by use of an adsorbent to selectively remove the cholesterol from the supercritical CO_2. The product can be reconstituted with water and fat to provide a reconstituted meat product suitable for hamburgers.

FIG.1.



EP 0 356 165 A1

Descripti n

Rem val of lipids from f odstuffs

FIELD

This invention relates to the removal of lipids from foodstuffs and in particular it relates to the production of reconstituted meat products. It has general application to the removal of sterols and/or lipid components from lipid containing foods, such as meat, fish, poultry and game, and dairy products, using high pressure fluids. It is useful in the preparation of low cholesterol or low fat foodstuffs.

BACKGROUND

Some meats have a limited market acceptance because of their strong flavour, or in some cases the unacceptable smell associated with the meat fat. Lamb is an example of this as it is not acceptable to many people and in particular is not readily marketable in Asia.

There is also concern over the level of fat and cholesterol in foodstuffs. In addition to concern over the presence of saturated fats in our diet, it is likely that legislation will be enacted in some countries which will require cholesterol content to be shown along with other nutritional values when the foodstuff is sold.

The primary source of cholesterol in foodstuffs is lipid-containing food such as meat, either red or white, fish and dairy products. Offal, such as brains or kidney, has a high cholesterol content but a relatively low lipid content.

The lipid components of interest are those known as neutral lipids. This class of lipids contains: mono-, di- and tri-acylglycerides, collectively known as fat; free and esterified cholesterol, and other sterols; free fatty acids, fatty alcohols and wax esters. Of most interest are the fat and cholesterol components.

These lipid components may also influence the flavour of the food, especially if the fat becomes rancid. Oxidation of fat destabilises the fat molecules giving rise to unpleasant flavours. The amount and type of fat present in the food is one of the limiting factors in storage of meats. Meats with a high proportion of unsaturated fats - fish, poultry, pork, lamb, and veal,- cannot be kept as long as beef. Some meats e.g. lamb because of their fat content have an unacceptable flavour.

PRIOR ART

High pressure physiologically acceptable fluids (especially supercritical fluids) have been used as solvents to extract natural materials for food and drug applications. Extraction with a high pressure fluid such as carbon dioxide offers advantages over conventional solvent extraction especially when applied to food as carbon dioxide is non toxic, non polluting, non flammable, and has bacteriostatic properties. Suitable high pressure extraction fluids include:

CO_2, N_2O, CF_3Cl, CF_2Cl_2, CH_2CF_2, SF_6, CHF_3, CHF_2Cl, CF_3Cl, CF_2CH_2, C_3F_8, ethane, ethylene, or mixtures thereof, and other gases unobjectionable from a health point of view, and which will be sub or supercritical in temperature and pressure ranges suitable for the processing of foodstuffs.

Liquid CO_2 and more especially Supercritical CO_2 have been used to extract caffeine from coffee, and flavourings from tea, chicory, fruit essences, herbs, and spices.

OBJECT

It is an object of the present invention to provide an improved process for the removal of lipids from foods.

SUMMARY OF THE INVENTION

In one aspect the invention provides a method of removing sterols and/or lipids from food including:

(a) drying the food to remove all or substantially all of the "free water" but not all of the "bound water" to produce an intermediate moisture product, and

(b) removing some of the sterols and/or lipids therefrom using a sub or supercritical physiologically acceptable gas.

By processing an intermediate moisture product as in step (b), the resultant low fat product can be reconstituted with fat and water to provide a flavour enhanced product and one which may also be low in chiolesterol.

In another aspect the invention provides an reconstituted meat product produced by the process of the previous paragraphs.

Thus this process allows for the production of reconstituted meat products, eg meat suitable for hamburgers. It has been found that the reconstituted product has an acceptable texture and an "improved" flavour.

Preferably the sub or supercritical physiologically acceptable gas is supercritical CO_2.

The moisture level is reduced to less than 60% w/w, and many different moisture removal techniques may be used. It is preferred that the food is dried to a moisture level in the range of 25-60% w/w. Where freeze drying of food flakes is adopted the moisture level is reduced to 30-55% w/w and more preferably to 30-40% w/w.

The at least partly dried low-lipid (and hence low cholesterol) food product can be stored in or transported in that form to save weight. Normally it will be reconstituted into a form acceptable to the consumer.

Optionally the cholesterol can be separated from th fat component and some of the cholesterol-free fat added back to the protein product prior to or during reconstitution of the food product.

In another embodiment the reconstituted meat can be blended from partly processed fat meat and from fresh lean beef to retain the natural meat colour. By this means it is possible to remove, say, approximately 80% of the cholesterol from the fat meat and then to blend it with fresh lean beef to obtain a 50% overall reduction in cholesterol.

The above gives a broad description of the present invention, a preferred from of which will now be described by way of example with reference to the accompanying drawings in which:

Figure 1: is a flow chart showing a first process for the removal of lipid components from meat;

Figure 2: is a flow chart showing a second process for the removal of lipid components from meat, with the option of separating the cholesterol from the fat and adding back some of the cholesterol-free fat to the meat during reconstitution;

Figure 3: is a graph showing the results of trials plotted to show the relationship between moisture content and percentage removal of fat;

Figure 4: is a graph showing the results of trials plotted to show the relationship between moisture content and percentage removal of cholesterol;

Figure 5: is a flow chart showing a third process for the removal of cholesterol from meat.

Figure 6: is a graph showing the relationship of extraction temperature to lipid removal.

Figure 7: is a graph showing the relationship of extraction pressure to lipid removal.

MEAT PRODUCTS

The preferred processes will be described with reference to meat products and in particular the provision of an intermediate moisture meat product or a reconstituted meat product suitable for hamburgers.

It has been discovered that the reduction in the moisture content of the meat to such a level that "free" moisture is removed results in supercritical CO_2 being able to penetrate and remove virtually all the ultra-muscular lipids and the majority of the cholesterol.

The published data for such a moisture level variously estimated is 39-40% to 26%, the precise figure varies with both type of breed and differs from species to species so that poultry for example has a different figure to the average beef figure. Our results compare favourably with the upper figure.

Under such conditions the extracted meat with fat added back retains its texture and generally has an enhanced flavour with minor acceptable change in colour, and its water-binding capacity. The colour can be allowed to re-bloom in the presence of oxygen (ie when the CO_2 has been removed).

Tasting of the reconstituted meat product revealed that the process can be used to change the strong taste of "grass-fed beef" to a milder taste approximating that of "grain fed beef" or in some cases the taste of veal. The process can also be used to vary the taste of mutton so that eg the flavour that is objectionable to people of certain ethnic groups can be removed or modified.

It has been discovered that contact with supercritical CO_2 under these conditions caused an unexpected dramatic reduction of bacteria from 10^4-10^5 units/gm to undetectable levels. Meat subject to this treatment has kept its colour and texture for at least four months at 5°C. If it is so required, such bacteria-free fat, after separation of cholesterol and deposition from the supercritical fluid may be removed or returned to the extracted meat.

Cholesterol may be removed from the supercritical fluid by passing the laden supercritical fluid through a bed of a suitable adsorbent. Adsorbents are known which can selectively remove cholesterol from fats. However in accordance with this invention there is provided a class of adsorbents which remove a higher percentage of the cholesterol. These adsorbents are selected from the group consisting of compounds of alkali metal, alkaline earth metal and transition metals (including zinc) and organic substances eg carbohydrates such as β-cyclodextrin. Using these adsorbents, the extraction process can be operated as a constant pressure recycle process.

In the latter option it may prove advantageous, largely on economic grounds to reduce the pressure of the extraction system to 100-150 bar, preferably 120-150 bar. Under these conditions the degree of extraction of lipid relative to that of cholesterol is substantially reduced.

The use of the supercritical solvent in this mode allows the replacement of some of the low-molecular weight substances that are found to produce cooking odours which are objectionable to some racial groups, as is the case with lamb or mutton. It is also possible to introduce other odour compounds eg by adding such compounds to an adsorbent material which is then eluted by the supercritical fluid steam prior to contact with the meat.

If required the fat level of the extracted meat can be reduced by any intermediate desired value by a combination of the above separation steps.

As a final step, if required, the residual CO_2 present in the meat and fat may be removed by vacuum stripping or purging with an inert gas such as nitrogen, if required.

CHOLESTEROL AND ANIMAL FAT REMOVAL

In Japan Patent No 59-135847 (to QP Corp) a process is described for the removal of cholest rol from foodstuffs. The specification states that the foodstuff needs to be dried to 15% or less water and pr ferably 2-8% to achieve high removal of cholesterol. A claimed advantage of the process is that significantly lower rang of fats and oils are removed than in traditional solvent extraction processes.

In the current application it was therefore surprising to find that lipids could be virtually completely removed by reducing the mositure level to only 30-40%, and that up to 80% of cholesterol could be extracted from lean meat under these conditions. The actual extraction of cholesterol would be significantly higher in meats of higher fat content. We have also discovered that this moisture level has a particular significance in the structural characteristics of the meat as is described below.

The economic significance of the above discovery is appreciable in that reduction of moisture levels to 30-40% requires about one-third to one-fifth the time to reduce moisutre levels in the same products to 2-8% as required by QP Corp. It also has a significant effect on other characteristics of the meat as is set out below.

The deleterious effects of freeze-drying meat are well documented:

Freeze-drying and Advanced food technologies
S.A. Goldblith, L. Rey and W.W. Rothmayr eds Academic Press New York, 1975
Chapter 18 Freeze-drying of sliced beef; N. Bengtsson

At the lower moisture levels referred to in the QP Corp patent, drying has the following effects:

1) changes take place in the protein structure and reduction in water-binding capacity results

2) non-enzymatic browning occurs on storage

3) oxidation changes occur to fat, protein and meat pigments. These changes lead to a taste described as "woody" in the rehydrated product (Penny et al Jn Sci Fd Agric 1963 Vol 14, Pg 535) and the re-hydrated product is generally tougher and dryer although the relative significance of these effects depends on both the method of re-hydration and the subsequent cooking process. Further details of the inherent problems of freeze-drying meat are set out in:

Processed Meats 2nd Edition AVI Publishing, Connecticut, A.M Pearson and F.E. Tauben

Water content is a major factor affecting the rate of lipid oxidation. Very low water contents in fat-containing foods is conducive to rapid oxidation. For example oat flakes dried at 180°C to a water content of 2.6% had a shelf life of less than 2 weeks but similar flakes with a water content of 10% were stable for 8 months. It has been shown that most foodstuffs exhibit oxidation rates that are strongly dependent on water activity with each system exhibiting its own characteristic minimum rate at an intermediate water activity. Moreover if foodstuffs (especially meat) are over dried, the physical properties of any reconstituted foodstuff are adversely affected.

It has been discovered that a reduction of the moisture level to a range from about 30% to about 40% moisture has significant structural implications for meat. In the following article:

Influence of the degrees of hydration on the thermal expansion of muscle tissue:
Monday M.J. and Mile C.A.
Intern. Jn. of Food Sci Tech 1988, 23, 177;

data is set out which implies that meat has a critical moisture content of 32-45% with a mean value of 39%. At levels above this value any moisture is present as "free" water whilst below this figure all water is "bound" to the protein structure. Other workers using quite different techniques have found the critical moisture content as 25-26%, the actual value varying between beef types and between animal species.

Thus it is postulated that removal of "free" mositure down to about 30% to about 40% or lower in some instances depending on the meat type allows penetration and extraction of the lipid containing material as well as a significant quantity of cholesterol.

Meat de-watered to this level has found to retain its original texture, its water-binding capacity and its organoleptic properties provided the de-hydration and extraction temperatures were held at 45°C or below.

Thus the current application involves a quite novel approach to extraction based on moisture content reduction to remove "free water" from the meat internal structure.

FREE WATER CONTENT

The "free water" and "bound water" content of meat is described by Reiner Hamm in "Biochemistry of Meat Hydration", in: Advances in Food Research, Vol. 10, 1960, pp 356 et seq.

The relative proportions of "free water" and "bound water" varies from meat type to meat type, and varies within species of animal. We have found that if the moisture content of the meat is reduced to about 30% to about 40% of the moisture content of the meat, substantially all of the "free water" will have been removed, and depending upon the meat type, a small percentage of the "bound water" may have been removed. The percentage of "free water" or "bound water" can be determined by the methods described by Reiner Hamm at pages 364-367 of "Biochemistry of Meat Hydration" or by Monday et al. It will thus be apparent to those skilled in the art, that the percentage of "free water" of a particular type of meat to be processed, can be readily determined, so that the amount of water reduction can be determined in order to optimise the production of an intermediate moisture product suitable for the removal of cholesterol and/or fats by means of sub or supercritical CO_2. If too much of the "bound water" is removed from the meat, the meat structure will be adversely affected, which in turn adversely affects the prospects of reconstituting the intermediate moisture product into a palatable product.

PREFERRED PROCESSES

Three processing schemes are shown, the first giving a product with low fat and low cholest rol (Figure 1), the second a low cholesterol product with the fat added back (Figure 2), and the third giving a low cholesterol product. The process steps are in numerical order:

1. meat preparation (including particle size reduction)
2. moisture removal,
3. extraction of the lipid components using a sub or supercritical fluid,

4A. optionally separation of the fat and the cholesterol from the sub or supercritical fluid,
4B. optionally separating the fat from the cholesterol,
4C. optionally separating the cholesterol from the sub or supercritical fluid by use of a selective adsorbent,

5. optionally adding some of the cholesterol-free fat back to the now low fat processed meat, and
6. finally reconstitution of the meat product by adding water and other additives. These process steps are described in more detail below.

PROCESS STEPS:

Process 1 (Figure 1). low cholesterol and fat product

1 Reduction in particle size

A supply of fresh, lean meat (which may be trimmed and deboned) is chopped, minced, sliced, flaked or diced to provide as large as possible surface area for drying (moisture removal). This is preferably carried out in an inert atmosphere, eg Nitrogen. As soon as the meat has been prepared in this manner, it is preferably stored in the absence of oxygen (eg in Nitrogen or in mixtures of Nitrogen and CO_2) in an appropriate fashion ready for the next stage.

The chopping, mincing, slicing, flaking, dicing, or the like of the meat, is preferably carried out in such a way that the size of the meat particle produced is not too small and that the exposed surface formed is not covered by a protein film that is thick enough to reduce the effectiveness of any following treatment step.

Basically, whenever, a previously unexposed surface is disrupted in any way, water soluble protein (myosin) is leached onto the surface. The protein film is "sticky" and this greatly aids in the rebinding of meat particles. However, the protein film is hydrophilic and forms an effective mass transfer barrier for the solvent (CO_2) and for lipid materials which are hydrophobic. Such a film is discussed below with reference to the reconstitu tion stpe 6.

Thus the reduction in particle size is preferably carried out by slicing or flaking frozen meat.

2 Moisture Removal/Drying: Options

A Partial Freeze drying

After the particle reduction step, the meat is spread in thin, even layers on freeze drier trays, and then frozen in an inert (eg Nitrogen) atmosphere at -10 to -20°C. The frozen material then can be partially freeze dried, preferably in the absence of oxygen. This can be conveniently carried out in a combination microwave/freeze drier, preferably drying the meat flakes to a moisture content in the range 30-55% w/w. The freeze dried material is then refrozen preferably in an inert atmosphere, in preparation for extraction.

B Moisture Removal using a Sub or Supercritical Fluid

After the particle reduction step, the meat at its original moisture content is preferably frozen in an inert (eg Nitrogen) atmosphere until ready for moisture removal. The sub or supercritical fluid (eg CO_2) is used at the extraction temperatures and pressures listed in step 3 to remove water. Upon reaching a certain moisture content, fat and cholesterol will also be extracted. The meat should be dried to the range 30-55% w/w. Note also that small amounts of entrainers, such as ethanol, propan-2-ol, and other low molecular weight liquids which are acceptable as food additives, may be used in a mixture with the sub or supercritical fluid. Moisture removal, using the above entrainers as solvents, is also possible.

C Moisture Removal using Heat (Cooking)

After the particle reduction step, the meat can be partially dried by the application of heat using traditional cooking apparatus, eg thermal oven or microwave but in all cases in the absence of oxygen. Also included in this step is the possibility of mechanical pressing after cooking which further reduces the moisture level. The moisutre level should be in the range 45-60% w/w and preferably in the range 50-55%.

Of the options available partial freeze drying (Option A) is the preferred method. The use of inert atmospheres is preferable where fatty meat is used, as this minimises the formation of sterol oxides which are deleterious to health and are not readily soluble in th sub or supercritical fluid of step 3.